Managing for cottonwood-willow riparian forests via physical process restoration

Julie Stromberg[1] and Sharon Lite[2]

Plant Biology Department[1] and
Geography Department[2]

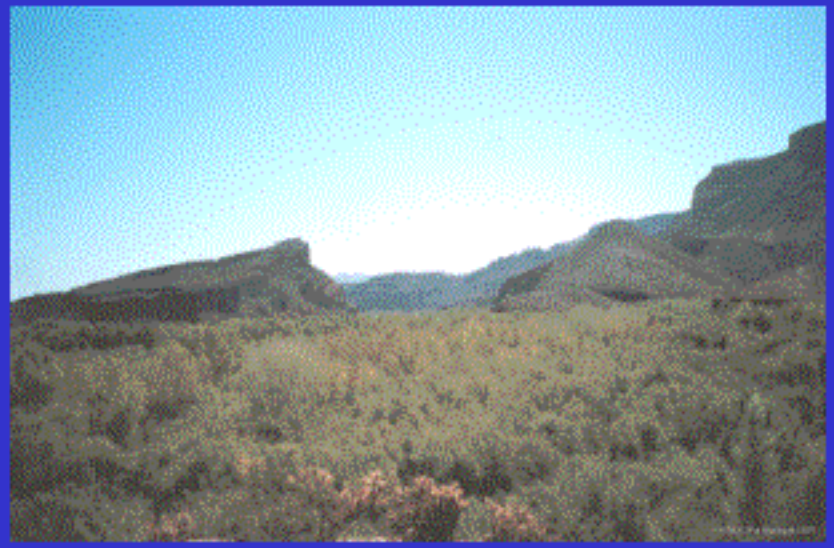
Arizona State University

Tempe AZ

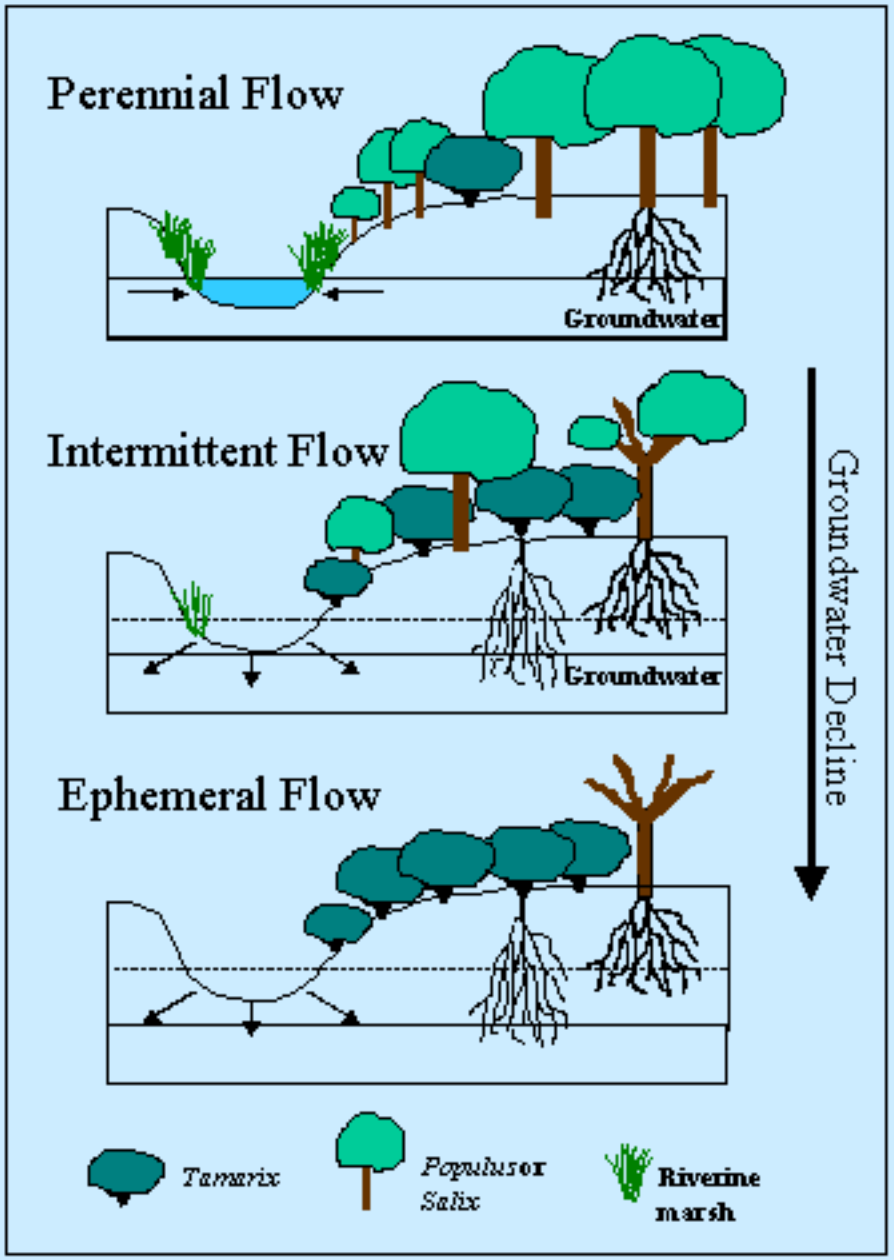
Southwestern Riparian Ecosystems: Anthropogenic Stressors

- Hydrologic alterations
  - Ground water decline
  - Surface water decline
  - Flood suppression
  - Flood timing change
- Water quality changes
  - Salinization
  - Nutrient enrichment
- Land use changes
  - Livestock grazing
  - Urbanization

Southwestern riparian ecosystems: Vegetation changes



Vegetation Composition Changes



Concerns About Loss of / Changes to Riparian Vegetation

Loss of desired ecosystem functions

- Loss of wildlife habitat
- Reduction in plant species diversity
- Aesthetic changes, loss of recreational opportunities
- Reduction in flood buffering and groundwater recharge functions

Restoration of Riparian Areas

- Goal: Restore and maintain hydromesic, pioneer tree species (e.g., cottonwoods and willows) and their functions.
- Options:
  1. Removal of exotic species
  2. Restoration of physical processes

Restoration Option 1: Focus on Exotic Species Removal

Exotic species abundance → Resource reduction, disturbance regime alteration, other environmental change

Resource reduction, disturbance regime alteration, other environmental change → Loss of native species and ecosystem functions

Saltcedar

Tamarix ramosissima

T. chinensis

T. ramosissima x T. chinensis

Fremont cottonwood

Populus fremontii

Methods for Exotic Species Removal

- Manipulating biotic interactions
  - Biocontrol insects
- Chemical
  - Herbicides. Aerial spraying of Arsenal, ground application of Round-Up
- Physical removal
  - Bulldozers, fire

Chinese leaf beetle (***Diorhabda elongata)***

Concerns with Exotic Species Removal

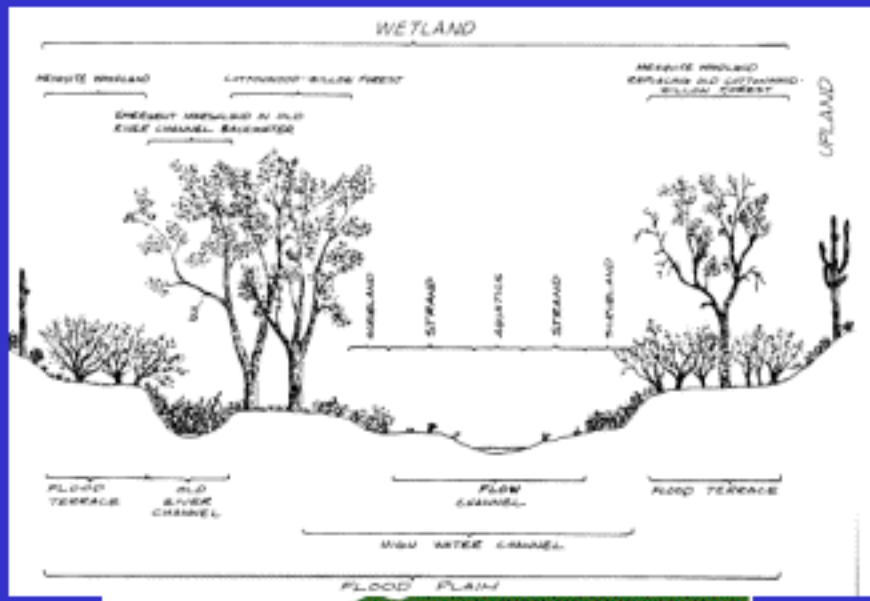
- Species removal alone is not a guarantee of ecosystem recovery

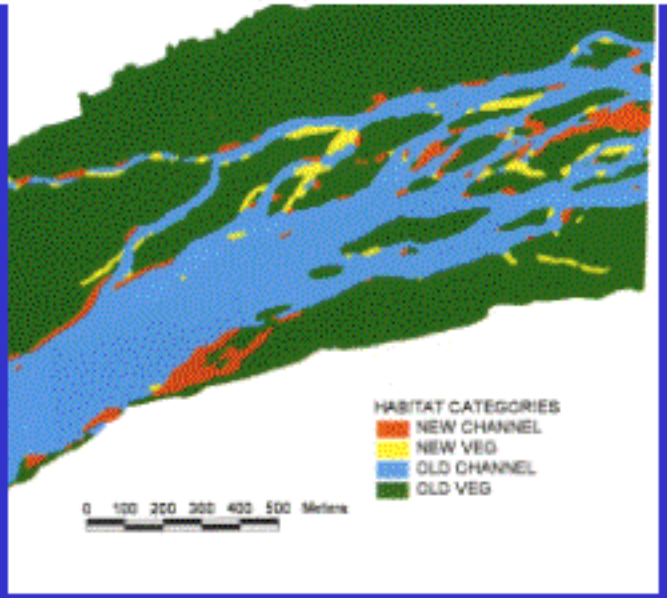
- Species removal without other restorative efforts may harm existing biota or alter ecosystem functions

Southwestern willow flycatcher
(*Empidonax traillii extimus*)

Spatial and temporal heterogeneity

?





Restoration Option 2: Ecosystem Model - Emphasis on Physical Processes and Conditions

Restoration Option 2: Restoring Ecosystem Processes

Resource reduction, disturbance regime alteration, other environmental change

Exotic species abundance

Loss of native species and ecosystem functions

Saltcedar

Tamarix ramosissima

T. chinensis

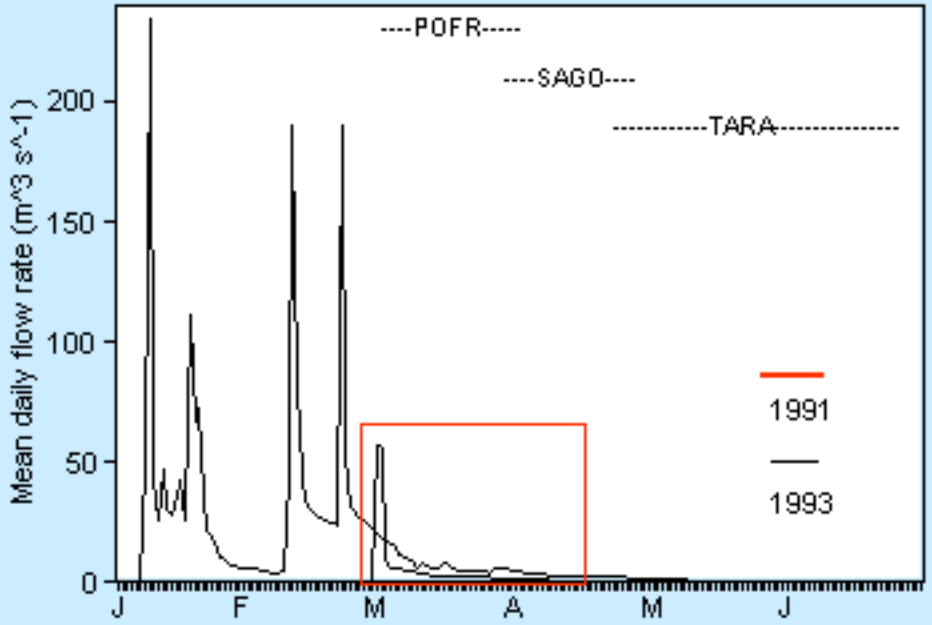
T. ramosissima x T. chinensis

Fremont cottonwood

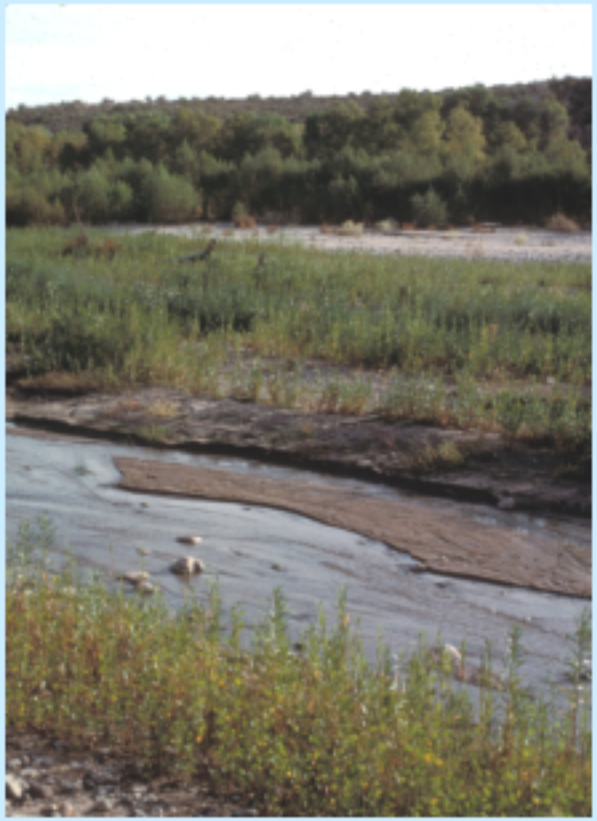
Populus fremontii

Pioneer Tree Establishment Conditions

- Fall, winter, or spring floods to mobilize and deposit sediments (geomorphic process of seed bed preparation)
- Slowly receding spring floods during seed dispersal period (hydrologic process of soil wetting for germination)

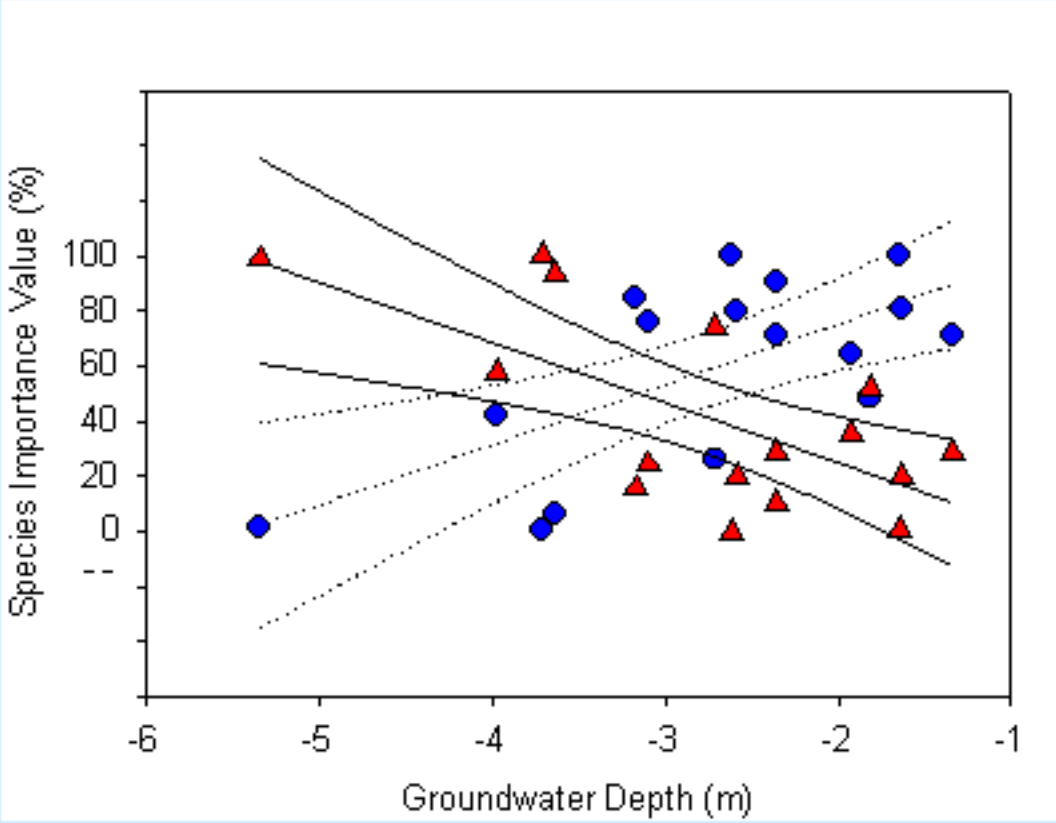


Hassayampa River, AZ



Pioneer Tree Adult Survivorship Conditions

Along San Pedro River, **cottonwoods and willows** were more abundant than **saltcedar** at sites where groundwater was shallow (<3 m) and stable (<0.6 m annual fluctuation) (Lite and Stromberg, in prep.)



Environmental Conditions Favoring Cottonwood or Saltcedar

	Cottonwood	Saltcedar
Hydrology		
Ground water depth-adults	<3 m	>3 m
Ground water fluctuation	<0.7 m	>0.7 m
Soil moisture- seedlings	Moist	Dry
Flood timing- germination	Spring	Late spring/summer
Flood frequency- seedling	Frequent?	Infrequent?
Water quality		
Salinity-germination	<5 dS/m	>5 dS/m
Salinity-plant growth	<2 dS/m	>2 dS/m
Nutrient content-seedlings	Low N/P?	High N/P?
Herbivory		
Livestock grazing -seedlings	No grazing	Grazing

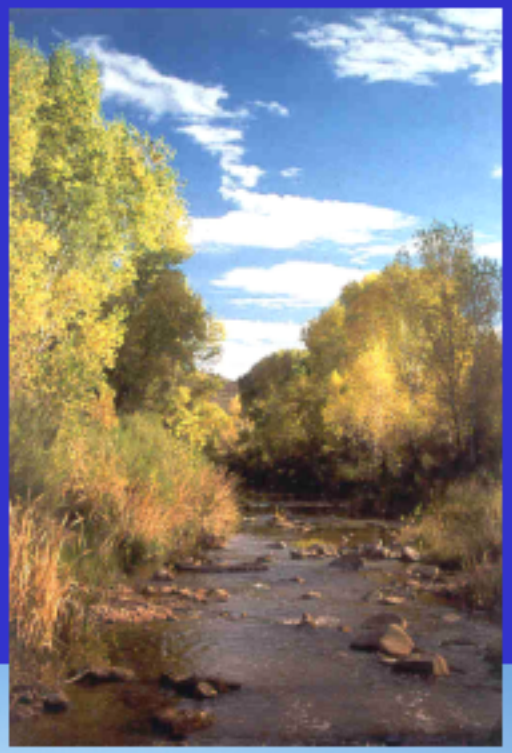
Example: Restoration of Floristic Biodiversity

1. **Species-based hypothesis**:
   - **Observation:** Low plant biodiversity in saltcedar patches, on flood-suppressed rivers (e.g, Lower Colorado)
   - **Interpretation**: Saltcedar reduces biodiversity, by causing environmental changes

2. **Ecosystem-based hypothesis**:
   - **Observation**: Higher understory plant diversity in saltcedar patches than cottonwood patches on free-flowing San Pedro River (Stromberg 1998; Bagstad et al. in prep)
   - **Interpretation**: Flood suppression on regulated rivers reduces plant diversity and allows for proliferation of saltcedar

Example of Ecosystem Restoration via Restoration of Physical Processes

- Conservation/mitigation purchase by TNC/USBR of Three-links farm along undammed San Pedro River, Arizona (6 river miles, 2,185 acres)
- Retirement of irrigated agriculture (historic pumping of 3,000 acre-feet per year)
- Predicted biohydrologic effects:
  - Restore perennial flows to 14 river miles
  - Cottonwood-willow regeneration after El-nino floods
  - Restoration of wetland herbaceous perennials
- Restoration cost: $2.8 million, $200,000 per river mile



Constraints: What If Processes Can Not be Fully Restored?

- Seed bed formation: Geomorphic process substitution
  - Use bulldozers to create channel depressions
  - Take advantage of bare agricultural fields or areas devegetated by stream dewatering
- Seed germination
  - Planned spring flood release from dam
  - Spring irrigation pulse from water control structures
  - Addition of seeds

Truckee River, Nevada: Spring flood for cottonwood regeneration

Considerations When Clearing Existing Vegetation

- Assess existing and projected physical site conditions, to determine potential for survivorship of species of 'higher functional value'
- Assess long-term maintenance requirements
- Step-wise, slow approach, to avoid large-scale (if temporary) loss of habitat for existing animal biota
- Adequate monitoring

Land and water management actions that influence relative abundance of saltcedar vs. Fremont cottonwood & Goodding willow

	Saltcedar	Cottonwood-Willow
Hydrology, water management		
Ground water pumpage	✓	
Ground water recharge basins, along floodplain habitat		✓
Surface water diversion	✓	
Water conservation		✓
Effluent recharge to channels		✓
Flood suppression, altered timing	✓	
Flood pulse restoration		✓
Water quality changes		
Salinization from reservoir storage, agricultural return flows	✓	
Flood pulses to reduce salt loads		✓
Floodplain land use		
Livestock grazing	✓	
Light recreation, conservation		✓